

# NEW GRADUATE BME CURRICULUM AT THE UNIVERSITY OF TECHNOLOGY BRNO

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**Abstract** In frame of a study reform, aiming at two-stage study system (BSc, MSc), a new two-year curriculum has been developed for students of biomedical engineering, including also basics of ecological engineering. This orientation becomes now an independent study branch in the MSc stage of study at the Faculty of Electrical Engineering and Communication, UT Brno. The contribution describes, in a level of detail, the concept of the curriculum, which seems to be a reasonable compromise under given constrains.

**Keywords** - Biomedical engineering, learning, tuition, curriculum of study, ecology

## I. INTRODUCTION

Study of biomedical engineering has a long tradition at the University of Technology Brno. It started already in 1967 as the so-called medical electronics branch of either electronic or control engineering. In the mentioned year, the Department of Medical Electronics was established, the predecessor of today's Department of Biomedical Engineering. This tradition is the oldest in the former Czechoslovakia (thus even in today's Czechia). Naturally, the concept of study has undergone many changes since then. Originally, medical electronics meant just emphasised orientation towards medical equipment in frame of either of the mentioned study frames; several optional specialised courses were offered. Later, it has been recognised, that certain background in biophysics and basic medical knowledge is also necessary. There was a tendency towards a specialised independent branch of study, but it started only shortly before 1989 and never reached maturity.

From today's point of view, the most important change of the concept appeared after the political change in 1989. In 1990, the scope of interest of the Department was broadened, as reflected in the change of its name to Dept. of Biomedical Engineering. At that time, the system of study at the Faculty of Electrical Engineering and Computer Science was reformed so that many rather narrow specialisations were substituted by a few more generic branches, of which three were important for biomedical engineering orientation: electronics and communication, control and measurement and computer science. The main idea was to produce broadly

oriented graduates, with solid theoretical background and ability to adapt to changing social environment during their professional life. In this frame, the Department of Biomedical Engineering offered a block of optional courses, after the passing of which the student was reasonably oriented in biomedical engineering without losing his general orientation. This way, the graduates were still engineers (MSc) of the broad orientation of electronics, measurement or computing (thus not limited to being employed only in the BME area) but with sufficient specialised knowledge and abilities to work in a hospital, a biomedical research or in design and production of biomedical equipment. The graduates, successfully finishing certain minimum choice of the BME courses obtained a certificate proving their enhanced competence in BME. This system enabled interested students to include the BME area into their curriculum without further obligations and has regularly attracted an appreciable interest - some 30 to 40 students a year.

In the last year, two phenomena substantially changed the situation. First, splitting the Faculty into two independent faculties: the faculty of electrical engineering and communication and the faculty of information technology. Simultaneously, the new university law requests subdividing the present five-year engineering study into two stages: the bachelor stage and the following master-degree stage. This situation has led to a complete change of the study system of BME, as will be in a greater detail described in the following paragraphs.

## II. BACHELOR - DEGREE STUDY

The three-year bachelor study at both new faculties preserves in principle the present system of BME study, naturally on only an introductory level. It means a very limited offer of basic specialised courses, while the general BSc frame provides widely oriented theoretical and engineering background in either electrical or computer engineering.

The medical background is represented here by the course Biology of man, summarising basic anatomy and physiology knowledge including medical terminology, and providing basic experience in practical medical measurements. An experienced professor of the medical faculty lectures the course; it is of crucial importance that the students become

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accustomed with the language and way of thinking of medical staff.

The technical background of biomedical engineering at the faculty of EE is represented by two optional courses: Diagnostic equipment and Therapeutic and prosthetic equipment. Both are providing basic overview on the used technology, more from the practical, user oriented point of view than from theoretical and design aspect, which has been postponed to the MSc stage.

In the information technology faculty, the offered specialised technical courses are also two: Medical informatics (hospital information systems, medical data analysis) and Sources of medical data (overview of medical equipment from the diagnostic-, measurement- and control data aspect).

Besides the mentioned three specialised courses, it is expected that the students of BME or medical informatics (MI) orientation will work on projects oriented into the biomedical applications.

After passing the bachelor's state exam, the undergraduates may obtain a certificate proving their (limited) BME or MI abilities, providing that they will have passed all the three courses, according to the faculty, and also a specialised part of the final state exam. The limited level of study is oriented towards basic technical support of medical electronic equipment or information systems in hospitals, towards trading and maintenance of the equipment, and also towards providing the routine interface between medicine and technology under different circumstances.

### III. MAGISTER - DEGREE STUDY

Separating the MSc stage of study led to a tendency to establish a greater number of narrower specialisations. Namely, at the Faculty of EE and Communication, the branch of biomedical and ecological engineering has been established under this situation. The idea to include also the ecological problems has emerged from two sources: primarily, the electronic and imaging technology used in ecology has much in common with the biomedical technology; also, there seems to be an increasing interest in ecology among students. The general recognition of importance of ecological aspects contributed to the decision.

The MSc study curriculum expects that the applicants have finished BSc degree in either electrical engineering or a similar area. A good knowledge of mathematics, physics, basic circuit theory and deeper computer literacy is substantial. Passing the biomedical courses offered for the BSc stage is advantageous but not necessary.

The suggested study plan of the specialisation can be seen on Tab.I. and Tab.II, for the first and the second year of study, respectively. Here, every sub-window represents a space for a course; a single course name means an obligatory course, more names separated by thin lines mean selectable courses. There are only a few optional courses offered (not in tables); due to very limited time space of two years only, the students have to concentrate to the indicated subjects.

The curriculum consists of several (partly overlapping) groups of courses. Starting from the least common group that nevertheless forms a spine of the BMEE branch, there are courses on non-technical disciplines: three medical plus one ecological courses. The medical courses are: Biology of man, compulsory for students who will not have passed it at the BSc stage, Clinical physiology as hospital application of the medical knowledge and Health care dealing with aspects of medical ethic as well as public and large-scale health services. All these courses are taught by medical specialists hired by the BME department. It is substantial, that the last two courses are taught in close co-operation with the Faculty hospital Brno so that the students have an opportunity to regular stays at different clinics and are exposed this way to the medical environment already during their engineering study. In a sense, a counterpart to this subject group is the Bionics course, presenting a technical view of biological systems. The basic ecological knowledge is presented in the course Introduction to environmental sciences, lectured by a leading professional environmentalist. Again, the corresponding technical view of this problematics, including the respective most important norms and regulations, is presented in the course Ecological engineering.

A group of advanced theoretical subjects is formed by the following courses: Biophysics, Statistics and operational research or Modern numerical methods, Circuit theory or Modelling and Identification, Signal and image analysis, Modelling of biological systems (including populations etc.). These courses provide a background for the specialised technical courses.

The core of the specialised engineering knowledge is presented in courses forming the applied technology group, the first two being Diagnostics of bio- and ecosystems (the principles of equipment, design and implementation approaches), and Special medical and ecological technology (including therapeutical, life-function support and prosthetic technology, control and laboratory/cleaning/sterilising technology). The third course in the line is devoted to design, maintenance, calibration and management of complex technical systems, used in medicine and ecology. Also, two imaging technology courses belong to this group: the first dealing with classical systems (X-ray, ultrasound, optical, infrared, etc.) while the other devoted to tomography of all used modalities (e.g. CT, MRI, SPECT, PET, impedance). The course on basics of management and marketing in health-care may also be counted to this technical group.

TABLE I

1st year of study	
Biology of man	Introduction to environmental sciences
Biophysics	Modelling of biological systems
Bionics	Ecological engineering
Circuit theory	Diagnostics of bio- and ecosystems
Modelling and identification	
Signal and image analysis	Classical imaging systems in medicine and ecology
Term project 1	Term project 2

TABLE II

2nd year of study	
Clinical physiology	Health care
Statistics and oper. analysis	Modern numerical methods
Signal processors	Computer/comm. networks
Computer aided diagnostics	Medical information systems
Biol. data analysis/ interpret.	Ecological inform. systems
Special medical and ecological equipment	Design and running of complex systems
Tomographic imaging systems	Management and marketing in health care
Diploma project	

The last important group consist of courses devoted to information technology in medicine or ecology: Computer assisted medical diagnostics or Analysis and interpretation of biological data, and courses on information systems, oriented either to health-care and hospital systems, or to ecological and regional information systems. A course on biosystem modelling belongs to this group as well, though being considered theoretical background as well.

An important part of the study is formed by the student projects: two term-projects and the final diploma project. It is stipulated that the projects will be oriented towards the area of either biomedical or ecological engineering. The projects may concern either hardware equipment design and testing or the y may be software-development oriented, often they include both areas in different proportion.

The curriculum is complemented by several other optional technical courses, like Signal processors, Computer and communication networks, Structure and properties of materials, Intelligent sensors etc.. The students are also invited to select from a choice of non/technical courses, like philosophical, law or art oriented, advanced languages etc.

So far, no MSc independent Medical Informatics study is envisaged at the new Faculty of information technology. Anyway, it is possible to choose relevant courses from a number of offered ones, partly offered also in frame of the above EE curriculum. It is supposed that the indipendent Medical informatics branch will be established after the faculty will have passed its initial period, providing a sufficient demand from students will exist.

### III. CONCLUSIONS

A new curriculum of biomedical and ecological engineering as designed for the new two-year MSc study plan has been presented. It is hoped to represent a reasonable selection of courses from both technical and human sciences. As this is a relatively specialised study, the success of this programme will, besides on the quality of tuition, depend also on the interest of students, which in turn will obviously be influenced by the demand from the biomedical equipment industry, medical research and health-care field or from the ecological management area.

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A note: Many study plans of more or less specialised university branches touching the field of biomedical and ecological engineering have been used and their positive influence is acknowledged.